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An Economic Study of Slow Growth of Crops in Pakistan: A Case of Pulses Production in Punjab

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Abstract

This study attempts to explain the growth trends and supply response behaviour of pulse crops in Punjab. The study examines the trends in area, production and productivity of gram, mung, mash, masoor and matar pulses, and also estimates the growth rates of area, production and productivity of different pulses. Moreover, we examine the response of supply of different pulses to changes in; relative price of the crop, relative yield of the crop, own price of the crop, own yield of the crop, gross irrigated area to gross cropped area, rainfall during the critical periods, price risk and finally, yield risk. Nerlovian partial adjustment lagged model has been used to test the factors influencing the farmers supply allocation. The results reveal that the slow growth in most of the pulses production can be mainly attributed to stagnation and decline in area.

I. Introduction

Technological change has given a face lift to the agricultural sector. It was well established by now that the change was confined to better endowed provinces and also to superior cereals (rice and wheat). These crops competed with the other crops for resources and were awarded better part of them, be it research or infrastructure. In result, this will hampered the growth of other crops to a considerable extent. Grain legumes[2] are one such crop group neglected and hence termed as slow growth crops.

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[2] *Grain legumes area all grain pulses, ground nuts and soybeans.*

Pulses, a main component of grain legumes, not only play a role of inexpensive protein supplier in the absence of relatively expensive animal proteins (meat, fish and egg) for majority of the population, but also carry out a much important task of soil fertility maintenance by supplying nitrogen to the soil through symbiosis in a cropping sequence. According to one estimate, pulses leave between 30 to 40 kg. of nitrogen per hectare in soil[3]. In spite of this, pulses are assuming a secondary status in the farmer's decision calculus.

Due to fluctuations/stagnation, the per capita availability of pulses has gone down to 0.0187 Kgs. per day in 2005-06, being 0.0207 Kgs. per day in 1975-76. This decline is due to an increase in population, on one hand, and a decline in the production of pulses on the other, which is largely affected by a decrease in the area under pulse crops. Other reasons for this decline are heavy dependence on rainfall, lack of new technology, poverty of farmers and an absence of infrastructural support. Nevertheless, the poor performance of pulses at the macro level is the result of farmer's decisions and actions vis-à-vis this crop. The farmers' approach to pulses crops in turn is conditioned by their characteristics, which are (1) low value status, (2) adaptation to poor habitat and resource base, and (3) production and consumption by the poorer members of society. The increasing gap between the demand and supply of pulses has led to sharp rises in their prices, which in turn are causing much hardship to the common man. This increasing gap is causing a serious concern to planners and policy makers in Pakistan.

All the provinces of Pakistan produce different kinds of pulses in varying quantities. Punjab is a major pulse growing province contributing 83 percent of area and 77 percent of production in Pakistan's total area and production of pulses during the year 2005-06. The main pulses produced are mung, mash, masoor and matar (lentils). Gram is also primarily used as a pulse. Share of different kinds of Punjab pulses in total pulses are presented in table 1. Area and production share of gram and mung shows an increasing trend while that of mash and masoor a fluctuating and decreasing trend between 1975-76 and 2005-06. The area share of matar crop was decreased where as its share in production increased over the time. As far as share of different kinds of Punjab pulses in their respective total pulses are concerned,

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[3] *For detail see; Oppen (1980)*

gram and mung share in area and production has increased between 1975-76 and 2005-06 (table 2 and figure 1).

Table 1: Share of Different Kinds of Pulses Produced in Punjab in Total Pulses

(Percent)

Years	Gram		Mung		Mash		Masoor		Matar	
	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production
1975-76	51.45	54.55	3.10	2.81	3.34	3.29	3.78	2.68	2.61	1.99
1980-81	51.26	49.18	3.49	4.22	4.89	5.96	4.60	4.67	2.88	3.67
1985-86	56.57	55.25	5.12	4.17	5.46	5.36	3.08	3.16	2.66	2.62
1990-91	56.14	55.05	7.73	6.19	4.69	4.38	3.00	2.57	2.49	2.99
1995-96	56.07	58.51	7.35	8.40	3.27	2.68	2.74	2.47	2.25	2.58
2000-01	58.68	53.88	14.93	14.92	3.04	3.54	2.12	2.88	1.78	2.93
2005-06	64.09	55.85	13.48	14.86	2.16	1.98	1.47	1.47	1.37	2.15

Source: Agricultural Statistics of Pakistan (different issues), Government of Pakistan, Islamabad.

Table 2: Share of Different Kinds of Pulses Produced in Punjab Pulses in Their Respective Total

(Percent)

Years	Gram		Mung		Mash		Masoor		Matar	
	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production
1975-76	71.11	71.08	68.05	68.96	84.59	86.58	76.68	74.20	25.65	23.60
1980-81	76.18	71.27	65.22	64.78	89.88	85.84	79.23	77.29	21.85	23.68
1985-86	79.46	75.09	71.40	60.04	89.19	87.50	77.87	80.51	27.39	30.78
1990-91	79.11	75.89	83.97	80.18	91.15	87.23	72.87	69.12	26.86	30.97
1995-96	80.13	79.09	87.44	85.21	89.86	86.62	67.02	66.76	25.35	30.27
2000-01	86.20	84.33	90.56	88.71	88.21	85.60	61.17	66.54	23.08	29.79
2005-06	87.48	79.77	90.79	89.38	87.86	82.42	61.06	56.42	21.37	28.05

Source: Agricultural Statistics of Pakistan (different issues), Government of Pakistan, Islamabad.

The share of gram in area and production has increased from 71.11 and 71.08 in 1975-76 to 87.48 and 79.77 percent respectively in 2005-06. Similarly the area and production share of mung increased from 68.05 and 68.96 percent in 1975-76 to 90.79 and 89.38 percent respectively in 2005-06. Masoor area and production share declined between 1975-76 and 2005-06. Mash area share increased while that of its production shares it decreased. Reverse is true for matar. There is thus an urgent need to review the performance of pulses crop developing a strategy to boost up their production across Pakistan in general and for Punjab in particular. In Pakistan except Ahmad (1983) and Syed (1973) no such study is available relating to this topic.

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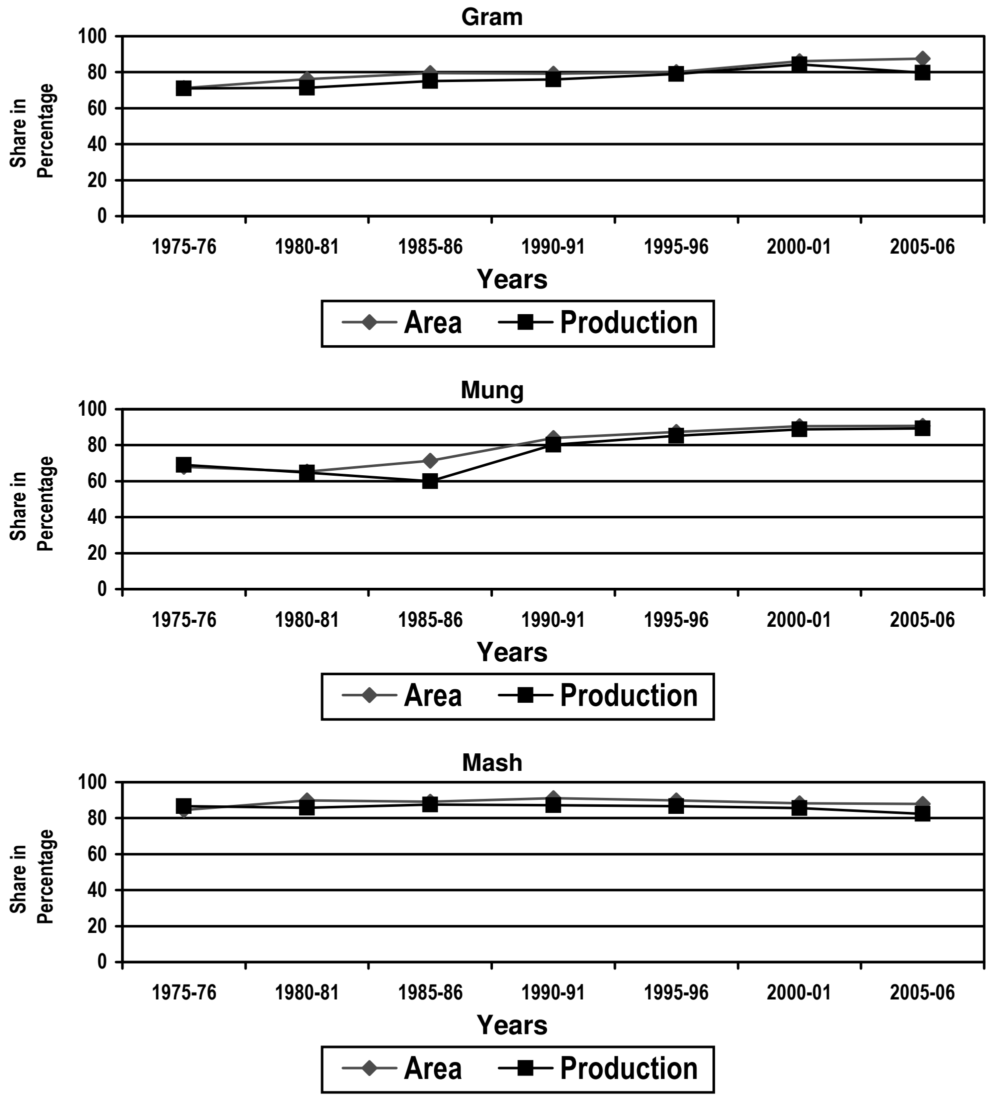
Figure 1: Share of Different Kinds of Punjab Pulses in their Respective Total Pulses



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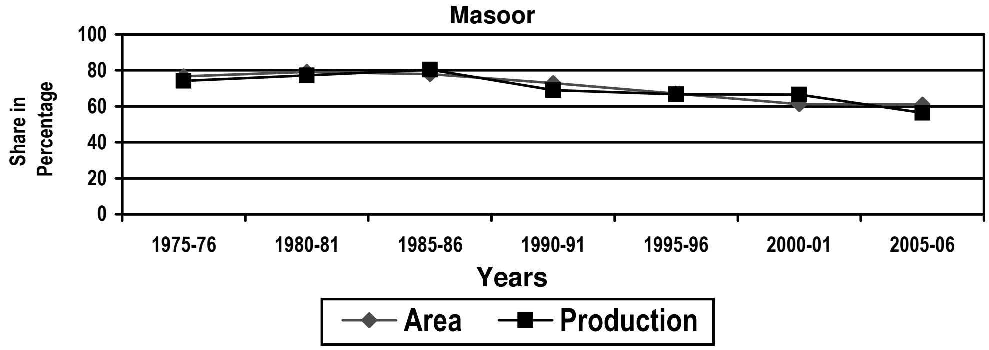

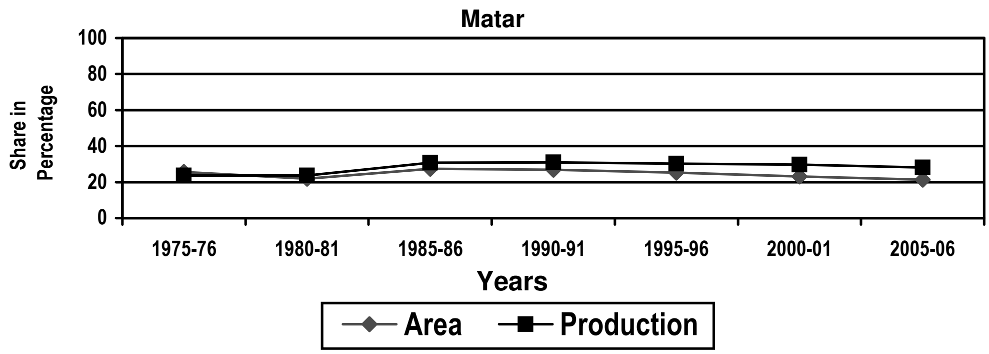

The specific objectives of this study are:

i) to analyze the trends in area, production and productivity of gram, mung, mash, masoor and matar pulses in Punjab

ii) to estimate growth rates of area, production and productivity of different pulses in Punjab

iii) to examine the response of supply of different pulses to changes in (1) relative price of the crop, (2) relative yield of the crop, (3) own price of the crop, (4) own yield of the crop, (5) gross irrigated area to gross cropped area, (6) rainfall during the critical periods, (7) coefficient of variations of the prices, and (8) coefficient of variations of the yield.

The rest of the paper is organized as follow; section II deals with data and study area, methodology of the study is discussed in section III, section IV is specified for results and discussion and last section V presents conclusion and policy implications.

II. The Data and Study Area

Five most important pulse crops (gram (chana), green gram (mung), black gram (mash), lentil (masoor) and field pea (matar)) produced in Punjab province are included in this study. The five crops together account for 83 percent of all pulses produced in Punjab. The study covers the time period starting from 1975-76 to 2005-06 for which data on crops acreage, prices, yields, rainfall, irrigation, etc., were collected from Agricultural Statistics of Pakistan, government of Pakistan. The study is confined to the province of Punjab in Pakistan.

III. Methodology of the study

1. Growth Rates

In order to examine the trend growth rates of pulse area, production and productivity, linear, exponential and semi-exponential functions were fitted. Semi log exponential form was finally selected considering the highest value of coefficient of determination (R^2). The form of semi log exponential function is as under:

$$\ln Y = a + bt \qquad (1)$$

Where:

Y = area/production/productivity of major pulse crops
A = constant
B = expresses the rate of change and when multiplied by 100 gives the percentage growth rate in area, production and productivity of major pulse crops
T = time period in years (1, 2, ……, n)

2. Acreage Response

In agriculture farmers decision plays an important role, but the transformation process involved in it, depending as it does on a number of uncontrolled natural inputs and human and animal labor, is more unpredictable than in industry. Farmers also face a number of constraints while making production decisions in response to changes in price and non-price factors. The farmer allocates his land to different crops, depending upon his expected revenues from it. Assuming that input costs are either the same or more uniformly distributed overtime for different crops, the expected revenue depends upon the expected price. It is seldom that farmer become able to make hundred percent adjustments while responding to various economic factors, or adjust instantaneously. In agriculture which is subject to weather uncertainties, or which is undergoing changes in production technology as in the case of some developing countries, such constraints become still more severe. Under such conditions the adjustment lagged model is considered appropriate for measuring farmers' response behaviour. Following Nerlove's seminal work[4] on the dynamics of supply response, this model has been widely used by a number of researchers[5] in agricultural supply response studies.

The long run supply A^*_t is assumed in the Nerlovian framework, to be related to P_t (the price) in a simple linear manner:

$$A^*_t = a + bP_{t-1} + U_t \qquad (2)$$

variations in A^*_t is connected by variations in observed or actual supply by assuming the following relationship between the actual and long run desired level of supply.

$$A_t - A_{t-1} = \beta (A^*_t - A_{t-1}) \qquad (3)$$

The current supply then is:

$$A_t = At_{-1} + \beta (A^*_t - A_{t-1}) \qquad (4)$$

β is the coefficient of adjustment, which accounts for forces which cause the difference between the short-run and long-run supply – price elasticities. $A_t - A_{t-1}$ is actual change and $A^*_t - A_{t-1}$ is desired or long-run change. The second equation is a behavioural relationship, stating that the desired acreage under the crop studied depends upon the relative farm prices in the preceding year. The fourth equation states that the actual planted area of crop in period *t* is equal to the previous actual planted area plus a proportion of the difference between desired planted area in period *t* and actual planted area in period t-1. This hypothesis implies that farmers cannot fully adjust their actual planted area to the desired area in response to changes in the explanatory variables

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[4] *See Marc Nerlove (1958, may 1958).*

[5] *Krishna (1963), Cummings (1975), Parikh (1972), Sangwan (1985), Khan and Iqbal (1982), Savadatti and Narappanavar (1997), Ahmad (1983), Rahman (1986), Sarup, Pandey and Verma (1983), Deshpande and Chandrashekar (1982), and Singh (1979).*

due to constraints such as fixity of assets, physical land conditions, habitual production patterns of farmers, etc. 'β' is, therefore, an indication of how fast the farmers are adjusting themselves to their expectations. The value of 'β' close to zero would mean that the farmer are slowly adjusting to the changing prices, yield etc. The value of 'β' close to one would mean that the farmers are adjusting quickly to the changing levels of prices, yield, etc. And the adjustment is instantaneously and perfect when $\beta=1$. In the real world however, the value of 'β' lies between 0 and 1.

The relationship between equations (2) and (3) give the reduced form, which eliminates the unobserved variable (A^*_t) by an observe variable (A_t).

$$A_t = A + BP_{t-1} + CA_{t-1} + V_t \qquad (5)$$

Where:

$A = a\beta$, $B = b\beta$, $C = (1\text{-}B)$ and $V_t = \beta U_t$

Equation (5) provides a simple version of partial adjustment model and the parameters of which can be estimated by the least-squares method if the original U_t's are serially uncorrelated (Gujarati, 2003). The advantage of partial adjustment model is that if the estimated residuals V_t of equation (5) are found to be serially uncorrelated, then U_t also become serially uncorrelated because $V_t = \beta U_t$. In result, the estimated coefficients are not likely to be affected by serial correlation. Therefore, OLS estimation of the partial adjustment model will yield consistent estimates although the estimates tend to be biased (in finite or small samples)[6]. Although A_{t-1} depends on U_{t-1} and all the previous disturbance terms, it is not related to the current error term U_t. Therefore as long a U_t is serially independent A_{t-1} will also be independent or at least uncorrelated with U_t, thereby satisfying an important assumption of OLS, namely, non-correlation between the explanatory variable(s) and the stochastic disturbance term. The reduced form would remain basically the same even if we include more independent variables than the ones included in equation (5).

Besides accounting for the 'lags' that occur in farmer's adjustment behaviour, the model postulated above also helps in the estimation of both the short-run and long-run supply elasticities.

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[6] *For details see, Ram D. Singh (1979).*

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Using the adjustment lagged model[7] as the basic frame of analysis, the response relationships in the study were estimated with the help of the following equation.

$$\text{Log } A_t = \log a + b_1 \log RLP_{t-1} + b_2 \log RLY_{t-1} + b_3 \log POC_{t-1} + b_4 \log YOC_{t-1} + b_5 \log AI_t + b_6 \log R_t + b_7 \log CV_p + b_8 \log CV_y + b_9 \log A_{t-1} + U_t \quad (6)$$

Where:

A_t	=	area under the pulse crop at time t (in hectares)
RLP_{t-1}	=	relative price of pulse crop to the competing crop at time t-1 (ratio)
RLY_{t-1}	=	relative yield of pulse crop to the competing crop at time t-1 (ratio)
POC_{t-1}	=	own price of the crop at time t-1 (Rs./40 Kgs.)
YOC_{t-1}	=	Own yield of the crop at time t-1 (per hectare)
AI_t	=	gross irrigated area to gross cropped area in rabi/khareef season (percentage)
R_t	=	rainfall during the critical periods (mid August to mid October for gram, May 15 to July 31 for mung and mash, September-November for masoor and matar)
CV_p	=	Coefficient of variations of the prices of the crop concerned for the years t-1, t-2 and t-3, used as a measure of price risk (in Rs.)
CV_y	=	Coefficient of variations of the yields of crop concerned for the years t-1, t-2 and t-3 used as a measure of yield risk (in Kg.)
A_{t-1}	=	area under the pulse crop at time t-1 (in hectares)
A^*_t	=	desired or long-run area under crop in year t
V_t	=	error term in year t
β	=	coefficient of adjustment

The log form of the function was chosen because of convenience. It provided direct estimates of supply elasticities besides saving in degrees of freedom. Incorporation of variables such as yield, irrigation and risks rather than concentrating only on the price factor as has generally been done in the past, is considered important to our understanding of the puzzle of shrinking acreage under pulses despite a rise in their prices.

[7] *For proof see, J. Johnston (1984).*

The study hypothesized that the price factor does not play a significant role in influencing the supply of pulses. This one is due to differences in inter-crop technological innovations, whether cost-reducing, or yield-increasing, or both, would change the input-output coefficients for different crops. These changes might be such that the price variable per se is related to the background. It is a fact that competing crops wheat and rice have, in recent years, witnessed technological break-through of much greater significance than any other crop. The resultant differentials in inter-crop yields have changed the pattern of relative profitability among the various crops. Therefore, it is plausible to expect that the price factor would play a weak role in influencing the acreage under pulses.

The hypothesis pertaining to irrigation was that it would cause a reduction in the area under pulses. With expansion in areas under assured irrigation, it is expected that the farmers will substitute crops like rice and wheat for pulses crops. Water requirements of the former crops (rice and wheat), especially the HYVs, are much greater than most of pulse crops. For the same reason rainfall was expected to have a similar effect on intercrop shifts in acreages.

Risks arising from both the price and the yield variations were expected to act as deterrent factors on acreages under pulses. The farmers were hypothesized to be risk averters. Because of the presence of lagged values of the dependent variable on the right hand side of equation (6), the Cochrane-Orcutt technique will be employed in the ordinary Least Square (OLS) regression procedure, in order to account for possible autocorrelation problems. The long-run price elasticities will be calculated by using the short-run price elasticities.

$$\text{Long-run price elasticity of acreage} = \frac{\text{Short-run price elasticity}}{\text{Coefficient of adjustment}}$$

Whether this model suffers from the auto-correlation problem or not, can not be tested by using the DW d-statistic, since the model includes a lagged-dependant variable (lagged acreage in this case) in the regression equation, the DW d-statistic is likely to have reduced power and biased toward the value 2, [Durbin (1970) and Nerlove (1958)]. For such an equation, Durbin has suggested an alternative test statistic known as Lag range Multiplier Test or the h-statistic[8], defined as:

$$h = \left[1 - \frac{1}{2}d\right]\sqrt{\frac{n}{1 - n\bar{v}(\bar{b}_9)}} \qquad (7)$$

Where:

$\bar{v}(\bar{b}_9)$	=	least square estimate of the variance of b_9.
d	=	usual DW d-statistic
n	=	number of observations

Under the null hypothesis of no autocorrelation, *h* is asymptotically normal with zero mean and unit variance. The test statistic can also be used to test the hypothesis of no serial correlation against first-order auto-correlation, even if the set of regressors in an equation contains higher order lags of the dependent variable. However, if $\bar{v}(\bar{b}_9) > \frac{1}{n}$, then h cannot be computed from this equation [Green (1990)]. "Inter-correlation of variables is not necessarily a problem unless it is high relative to the overall degree of multiple correlation" (Klein 1962). If there are strong interrelationships among the independent variables, it becomes difficult to disentangle their separate effects on the dependent variable. If there are more than two explanatory variables, it is not sufficient to look at simple correlations. Thus the term "inter-correlations" should be interpreted as multiple correlation of each explanatory variable with the other explanatory variables. Thus, by the Klein's rule, multi-collinearity would be regarded as a problem only if $R_y^2 < R_i^2$, where $R_y^2 = R_y^2.\times_1\times_2......\times_k$ and $R_i^2 = R_{\times i}^2.\,other\times' s$. A categorical test of inter-correlations among the explanatory variables was conducted that ensures the best linear unbiased (asymptotic) estimates (BLUE)[9].

[8] *The serial correlation is tested through 'h' statistics and the use of classical linear regression model (CLRM) incorporating the assumption that U_t is distributed identically and independently with zero mean and constant variance (Jai Krishna and Rao, 1967, Sawant, 1981).*

[9] *For detail see, appendix table 1.*

IV. Results and Discussion

Before discussing the results, we have analyzed the figures for the period of 1975-2006 to show the trends in area, production and productivity[10]. Data shows that the area under gram though increased at the end of the study period but recorded a fluctuating trend between 1975-76 to 2005-06. Production and productivity of the crop in the majority of the years recorded a declining trend. The highest area, production and productivity of gram were recorded in the year 2004-05. The area and production of the crop Mung shows an increasing trend during the study period. The highest area and production was recorded in the year 2002-03 and 2003-04. Productivity of the crop though increased but at a decreasing rate. The area, production and productivity of the crop Mash recorded a decreasing trend during the study period. The area, production and productivity which were 49400 hectares, 25800 tonnes, and 526 kg/hectares respectively in 1975-76 decreased to 30400 hectares, 13600 tonnes and 447 Kg/hectares in 2005-06.The area and production of the crop Masoor recorded decreasing trend, while that of productivity an increasing trend. The area under the crop Matar increased up to 1990-91, after that it recorded a decreasing trend. The production of the crop in majority of the years recorded an increasing trend. Productivity of the crop recorded an increasing trend which implies that farmers were utilizing farm inputs efficiently while the climatic conditions were also suitable for the crop.

1. Output Growth of Crops

The results presented in table 4 show that the production of gram increased at a rate of 1.57 percent per annum, mung at 6.92 percent per annum and matar at 0.31 percent per annum. The increase in the production growth of gram was due to increase, both in area growth and productivity growth, but the productivity growth contributed more as compared to the area growth. It means that farmers were utilizing farm inputs efficiently and timely. The increase in mung production growth was mainly due to increase in its area growth rather than productivity growth. This implies that the mung producing farmers are also utilizing the area of mash. In case of matar, the increase in its production growth was mainly due to increase in its productivity growth. This might be due to favourable climatic conditions and utilization of better farm

[10] *For detail see, appendix table 2.*

technologies. Mash and Masoor recorded negative growth rates in area and production as against positive growth in Masoor productivity. It means that wheat farmers are increasing their area by taking it out from Matar and Masoor. The major conclusion of this table is that in most of the pulse crops the growth in production was mostly due to growth in productivity rather than area.

Table 4: Compound Growth Rates for Area, Production and Productivity of Major Pulse Crops in Punjab (1975-76 to 2005-06)

(Percent per annum)

Crops	Area	Production	Productivity
Gram	0.538 (2.937)*	1.574 (2.451)**	1.036 (1.810)***
Mung	6.680 (22.05)*	6.925 (26.11)*	0.256 (1.247)
Mash	-1.184 (2.386)**	-1.327 (2.935)*	-0.145 (0.745)
Masoor	-2.953 (7.563)*	-0.989 (2.421)**	1.959 (6.996)*
Matar	-2.550 (9.045)*	0.314 (2.197)**	2.336 (23.30)*

*, **, *** *Significant level at 1, 5 and 10 percent, respectively. Figures in parentheses are 't' values.*

2. Acreage Response Analysis

The results of the estimated regression coefficients of supply response functions for major pulse crops in Punjab are presented in table 5.

(i) Relative and Own Price

Except gram, the impact of relative price variable has been either too weak or even negative in some cases (masoor and matar). The impact of the economic incentives on gram and mash acreage is found to be significant, as is evident from the significant positive impact of relative price on gram and own price on mash acreage. For gram, the variable is significant at 1 percent and for mash it is significant at 10 percent. For mung, masoor and matar the relative price variable is insignificant. The positive sign of the variable suggests that additional income from the crop in the preceding year has generally led to higher investment in the acreage of gram and mash in the

Punjab province. This in a way suggests that for a producer, growing competing crops mainly for family consumption is of little importance. The farmer would generally like to meet his subsistence requirement out of his own farm to feel secure. An excess production over subsistence requirements in a good year of the competing crop is generally saved for future consumption rather than sold out. This means that market price has a potential to increase gram production. The negative relative price coefficients of masoor and matar though statistically insignificant show illogical economic relationships. The results have to be interpreted in the background of the fact that the continuously declining acreage has been accompanied for Masoor and matar crop under study with rising prices of these crops over the last decade. It is also a fact that the price factor has almost been over-swamped by the non-price factors such as technological changes in competing crops (wheat, gram) in influencing shifts in inter-crop acreages. Ram D. Singh (1979), Kusum Chopra (1982), R.S. Deshpande and H. Chandrashekar (1982), and Bashir Ahmad (1983) observed a mixed pattern of positive and negative responses of price variable for different pulse crop.

(ii). Relative Yield

The impact of relative yield variable is positive and significant only for gram crop at 5 percent level. However for masoor and matar it is negative and statistically significant at 5 percent level. The negative impact of the yield should be considered in the context of spread of HYVs of seeds of the competing crop, wheat.

(iii). Irrigated Area and Rainfall

The ratio of gross irrigated area to gross cropped area is positive and significant for mung and matar crop at 5 percent level of significance. Mung and matar are mostly irrigated crops. It means that with expansion in irrigation facilities the farmers of mung and matar crop will increase the crop area. That’s why the rainfall variable of these two crops is statistically non-significant. The rainfall variable has no effect on these crops acreage. Gram, mash and masoor are mostly un-irrigated crops. Therefore the irrigation variables of these crops are statistically non-significant. There effects are captured in rainfall variable. The variable is statistically significant at 5 percent level. Increase in rainfall will increase gram, mash and masoor crop area.

(iv). Risk Variables

Changes in acreage allocation and cropping pattern involved risk. Generally, such changes give rise to two major sources of risk, one arising from fluctuations in prices and the other pulses variation in yield. How farmers have varied acreage under crops in response to these risks is important to know. On one hand, fluctuation in prices reflects conditions of demand and supply including uncertainties and imperfections in marketing systems. Variability in yield, on the other hand, is caused by weather conditions, as is the case for most of the crops in Punjab or by changes in production technologies. The relative incidence of these risks may differ among individual crops. The variability due to price and yield gives expected negative sign for all the crops. The price risk coefficient is significant at 5 percent level only for mung crop. For all other crops though the coefficients are negative but statistically insignificant. The significant negative sign of price risk variable for mung crop indicates that mung growing farmers appear to be risk-lovers by putting less acreage under the crop. The variability due to yield upholds our expectation (negative sign) for all the crops. The coefficient is significant at 5 percent level for gram, masoor and matar crop, while for mung, it is significant at 10 percent level. It means that farmers of these crops keep in mind the weather conditions and changes in production technology.

(v). Lagged Crop Acreage

Lagged gram and Mung acreage has positive and significant impact, indicating slow adjustment response on the part of farmers. For mash and matar crop, lagged acreage has negative and significant influence, indicating an over adjustment of planted acreage to the desired acreage.

(vi). Adjustment Behaviour and Short-Run and Long-Run Relative Price Elasticities

As our model is based upon Nerlove's adjustment hypothesis, it will be interesting to know how far the estimated equations for actually planted area support this argument. The rapidity with which the farmers adjust the acreage under a crop in response to movements in factors discussed above, is

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Table 5: Estimated Regression Coefficients of Supply Response Functions for Major Pulse Crop in Punjab

Crop	Competing Crop	Intercept	Regression Coefficients									Coefficient of Adjustment	Multiple Coefficient of Determination	Durbin 'h' Statistics	Relative Price	
			Relative Price in t-1	Relative Yield in t-1	Own Crop Price in t-1	Own Crop Yield in t-1	Gross Irrigated Area/Gross Cropped Area in *t*	Rainfall in *t*	Price Risk	Yield Risk	Crop Acreage in t-1				Short-Run Elasticity	Long-Run Elasticity
Gram	Wheat	4.313	0.603 (3.416)*	0.274 (2.341)**	–	–	-0.132 (1.022)	0.631 (2.561)**	-0.156 (1.316)	-0.268 (2.183)**	0.597 (2.332)**	0.403	0.95	0.322 (NSC)	+0.603*	+1.496*
Mung	Rice	3.756	0.162 (1.432)	–	–	–	0.432 (2.211)**	0.131 (1.211)	-0.213 (2.193)**	-0.196 (1.983)**	0.286 (1.962)***	0.714	0.86	0.421 (NSC)	+0.162	+0.226
Mash	None	2.113	–	–	0.189 (1.871)***	0.132 (1.392)	-0.129 (1.041)	0.549 (2.312)**	–	–	-0.259 (2.316)**	1.259	0.81	-0.219 (NSC)	+0.189[a]	+0.150[b]
Masoor	Wheat	3.516	-0.039 (1.325)	-0.267 (2.416)**	–	–	0.123 (1.361)	0.411 (2.210)**	-0.129 (1.512)	-0.213 (2.314)**	0.139 (1.421)	0.860	0.92	0.513 (NSC)	-0.039	-0.045
Matar	Wheat	4.619	-0.126 (1.395)	-0.321 (2.519)**	–	–	0.325 (2.516)*	-0.116 (1.161)	-0.131 (1.456)	-0.219 (2.410)*	-0.316 (2.411)**	1.316	0.89	0.362 (NSC)	-0.123	-0.095

Figures in parentheses are 't' values. *, ** and *** shows level of significance at 1, 5 and 10 percent, respectively.
a Short-run own price elasticity.
b Long-run own price elasticity.
NSC No serial correlation.

seen from the numerical values of the coefficient of adjustment (β). For the entire pulse crop studied (gram, mung, mash, masoor and matar), lagged dependent variable (A_{t-1}) for gram and mung entered positively and for mash and matar, it entered negatively. The adjustment coefficient of mash and matar is outside the assumed range of zero to one. Hence mash and matarindicates over-adjustment to the desired change in acreage. The adjustment coefficient of gram (0.403) and mung (0.714) are within the assumed range of zero to one. This low rate of adjustment coefficient points out that gram and mung farmers in Punjab are significantly influenced by institutional and technological constraints while expanding or contracting area under these crops and that price inducement operated slowly and gradually.

The long-run elasticity with respect to relative price is higher than short-run elasticity for gram crop. It means that gram growers of Punjab have more time to adjust their acreage under the crop in the long-run than in the short-run. For mash crop the case is just the opposite.

V. Conclusions and Policy Implications

The present study has been directed to find out the trend growth rates and identifying economic and non-economic factors responsible for variations in major pulses acreage in Punjab. The growth trend and supply response analysis shows that an increase in the production growth of gram was due to increase, both in area growth and productivity growth, but productivity growth contributed more as compared to area growth. The increase in Mung production growth was mainly due to increase in its area growth, rather than productivity growth. It means that Mung growing farmers are also utilizing the area of mash crop. The increase in matar production growth was only due to increase in its productivity growth. Utilization of better farm technologies and favourable climatic conditions are the major factors in its growth. Masoor pulse recorded negative growth rates in area and production as against positive growth in its productivity. It means that wheat growing farmers are increasing their crop area at the expense of matar and Masoor area. In most of the pulse crops, the growth in production was mostly due to growth in its productivity rather than area.

The Acreage Response Analysis reveals that in the process of making the area decisions for gram, Mung, Mash, Masoor and matar cultivation, all the variables i.e. relative and own price, relative yield, irrigated area, rainfall, risk variables and lagged acreage are not equally important for all the pulse crops. The impact of the economic incentives on gram and mash acreage is found to be significant, as evident from the significant positive impact of relative price on gram and own price on mash acreage. For Mung, Masoor and matar, the relative price variable is insignificant. For Masoor and matar it is also negative. The positive sign of the variable suggests that additional income from the crop in the preceding year has generally led to highest investment in the acreage of gram and mash. The farmer would generally like to meet his subsistence requirements out of his own farm to feel secure. An excess production over subsistence requirements in a good year of the competing crop is generally saved for future consumption rather than selling it. This means that market price has potential to increase gram and mash production. The negative relative price coefficient of Masoor and matar though statistically insignificant show illogical economic relationships. The reason is that the price factor has been almost over-swamped by the non-price factors such as technological changes in competing crops (wheat, gram) in influencing shifts in inter-crop acreages.

The impact of relative yield variable is positive only for gram crop, while for Masoor and matar pulse it is negative. The negative impact of the yield should be considered in the context of spread of HYVs of seeds of competing crop, which is wheat. The ratio of gross irrigated area to gross cropped area is positive and significant for Mung and matar crop. It means that with expansion in irrigation facilities the farmers of Mung and matar crop have increased the crop area. The rainfall variable is positive for gram, mash and Masoor crop. It means that increase in rainfall increases the area of these crops.

The slow growth in most of the pulse crops production (especially matar and masoor) can be attributed mainly to stagnation and decline in area. Therefore, production of these crops can be increased through the widespread use of improved seeds, introduction of higher yielding varieties, adoption of improved methods of cultivation and better control of pests and diseases. In order to increase matar and masoor production, the government needs to provide HYVs at minimum prices to farmers. The price and risk factors will need to be considered, though appropriate measures in order to provide the necessary incentives to the producers for maintaining pulse acreage at desired levels. An appropriate policy will therefore require that the farmers should be

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assured of a good but stable return from the crop and necessary infrastructural facilities for ushering in modern agriculture with new agricultural practices. An indirect policy implication is that, since dairy and poultry products may provide good substitutes to counter nutritional deficiencies arising from the scarcity of pulses, efforts are needed to be directed towards the promotion of enterprises like dairy and livestock in agriculture.

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Appendix Table – 1
Test of Multicollinearity of the Explanatory Variables
(By Klein's Rule) Used in the Regression Analysis of Pulses

Pulses		Partial R^2 (Each Explanatory Variable as a Dependent Variable)								
	Total R^2	Relative Price	Relative Yield	Own Crop Price	Own Crop Yield	Irrigated Area	Rain fall	Price Risk	Yield Risk	Crop Acreage
Gram	0.95	>0.52	>0.35	–	–	>0.49	>0.46	>0.61	>0.38	>0.56
Mung	0.86	>0.39	>0.42	–	–	>0.52	>0.51	>0.35	>0.42	>0.51
Mash	0.81	>0.46	>0.51	>0.43	>0.38	>0.41	>0.44	>0.46	>0.45	>0.52
Masoor	0.92	>0.43	>0.61	–	–	>0.52	>0.48	>0.49	>0.51	>0.43
Matar	0.89	>0.47	>0.39	–	–	>0.46	>0.43	>0.51	>0.46	>0.45

Each explanatory variable used as dependent variable, in turn, on other explanatory variables (according to the model type of the Table Equation). If the partial R^2 is greater (>) than the total R^2, then there is harmful multicollinearity of the variable on the other variables conversely, (i.e. R^2 total >R^2 partial), the collinearity problem is not serious (see Maddala, 19767). The associated symbol of the explanatory variables, i.e. > indicates that the total R^2 is greater than the partial R^2. All the variables are in natural logarithms.6

Appendix Table – 2
Area, Production and Productivity of Different Kinds of Pulses (Gram, Mung and Mash) in Punjab during 1975-76 to 2005-06

Years	Gram			Mung			Mash		
	Area (Hectares)	Production (Tonnes)	Productivity (Kg/hectare)	Area (Hectares)	Production (Tonnes)	Productivity (Kg/hectare)	Area (Hectares)	Production (Tonnes)	Productivity (Kg/hectare)
1975-76	759700	427500	563	45800	22000	480	49400	25800	526
1976-77	785700	465000	892	40300	18900	468	40300	20900	519
1977-78	817100	449700	550	42500	20400	480	43100	22600	523
1978-79	934400	398800	427	39800	17600	443	40900	19800	485
1979-80	870500	213100	245	46600	21900	467	57000	28300	497
1980-81	642100	240100	374	43700	20600	472	61300	29100	474
1981-82	700100	159300	228	40800	19500	477	59100	28000	474
1982-83	679800	353400	520	49700	24600	495	63900	30000	471
1983-84	711400	380600	535	60100	26000	433	60900	33000	542
1984-85	795900	379600	477	63800	28200	457	73900	41000	555
1985-86	821100	440200	536	74400	33200	446	79200	42700	539
1986-87	859800	430500	501	81300	37700	464	69100	33200	480
1987-88	642400	246600	384	71900	32400	451	68600	31400	458
1988-89	763400	294100	385	76400	31400	411	72000	28000	389
1989-90	815600	396700	486	119500	45200	378	79300	35300	445
1990-91	863500	403000	466	118900	45300	381	72100	32100	445
1991-92	792800	390900	493	104800	40000	382	73000	32400	444
1992-93	820000	227000	276	122500	48400	395	70000	25700	366
1993-94	844700	286400	339	147400	57600	391	58700	24500	417
1994-95	846100	425400	502	153800	67400	438	48200	22700	472
1995-96	896600	537500	599	174100	77200	443	52300	24600	471
1996-97	906400	472600	521	172500	78700	456	52300	25100	480
1997-98	908300	646200	711	166300	72000	433	43400	22100	509
1998-99	887600	577700	651	170700	75100	440	39700	21200	533
1999-2000	809200	465500	575	179600	82000	457	37900	20000	529
2000-01	780100	334800	429	198500	92700	467	40400	22000	545
2001-02	816000	304200	373	215800	102000	472	49300	23800	484
2002-03	860000	611500	711	237300	125700	530	50800	25800	509
2003-04	854400	524000	613	231000	126800	549	43600	21300	488
2004-05	956400	760600	795	206600	118300	573	33200	15500	467
2005-06	900100	382500	425	189300	101800	538	30400	13600	447

Source: Agricultural Statistics of Pakistan (different issues), Government of Pakistan, Islamabad.
Note: Table 2 continue……….

Appendix Table – 2 (continued)
Area, Production and Productivity of Different Kinds of Pulses (Masoor and Matar) in Punjab during 1975-76 to 2005-06

Years	Masoor			Matar		
	Area (Hectares)	Production (Tonnes)	Productivity (Kg/hectare)	Area (Hectares)	Production (Tonnes)	Productivity (Kg/hectare)
1975-76	55900	21000	378	38600	15600	406
1976-77	62500	23200	371	47800	19900	417
1977-78	74600	26900	360	44700	19100	427
1978-79	88400	30900	350	51300	21800	425
1979-80	68600	28500	415	39000	18700	479
1980-81	57600	2800	396	36100	17900	496
1981-82	53500	22100	413	43100	21400	496
1982-83	60700	20100	331	38900	19400	497
1983-84	35500	15500	436	44400	23100	520
1984-85	36300	20000	553	43000	21400	497
1985-86	44700	25200	565	38600	20900	542
1986-87	66200	25100	378	41300	22100	535
1987-88	60000	23200	388	36600	20300	554
1988-89	58400	24600	421	39900	22000	552
1989-90	50900	21800	428	39400	22900	580
1990-91	46200	18800	407	38300	21900	572
1991-92	40300	17100	424	37300	21500	576
1992-93	45100	19000	421	37600	21600	576
1993-94	32200	15500	480	34500	21400	619
1994-95	41900	21300	508	32500	21000	646
1995-96	43900	22700	517	36000	23700	659
1996-97	47800	23600	495	36000	23200	645
1997-98	43400	25600	590	33000	25400	772
1998-99	37000	26400	713	30500	24300	797
1999-2000	34900	25500	731	30900	24600	794
2000-01	28200	17900	635	23700	18200	768
2001-02	28800	18300	637	26500	20800	786
2002-03	34200	21600	630	21700	17400	801
2003-04	35300	22000	623	19800	15500	783
2004-05	28000	17200	614	17900	13900	777
2005-06	20700	10100	488	19300	14700	762

Source: Agricultural Statistics of Pakistan (different issues), Government of Pakistan, Islamabad.